Marine Inventory Updates

- Marine categories include ocean-going vessels (OGV), commercial harborcraft (CHC), and other
- OGV and CHC have been significantly improved
 - Comprehensive statewide approaches
 - Replacing district categories
 - Designed for detailed analysis; regulatory support
 - Very high spatial resolution
 - Based on new surveys and data collection
 - Bottom-up approach

Ocean-Going Vessels Update

Lead Staff: Andrew Alexis

OGV Overview

- Statewide, spatially refined, bottom-up approach
- Eight vessel types:
 - Container, Bulk, General Cargo, Refrigerated, Roll-on / Roll-off, Automobile Carrier, Tanker, Passenger
- Three emissions source types
 - Propulsion Engines, Auxiliary Engines, Boilers
- Emissions out to 100 miles from shore

OGV Emissions Calculations

- Bottom-up approach
 - Vessel, trip, & port-specific
- Emissions = Act * Pop * EF
 - Act = Activity
 - Pop = Vessel population
 - EF = Emission factor
- Activity = Time * Power * LF
 - Time = Time-in-mode
 - Power based (i.e. kWhrs)
 - LF = Load Factor

OGV Operating Modes

- In-Transit
 - Main propulsion unit
 - Auxiliary engine
- Maneuvering
 - Main propulsion unit
 - Auxiliary engine
- Hotelling
 - Auxiliary engine

OGV Population and Activity Sources

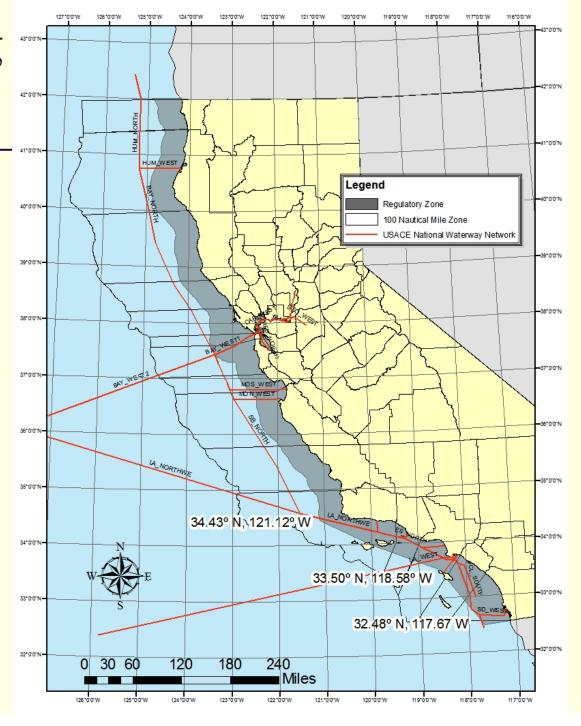
- Port calls by vessel name/type
 - 2004 State Lands Commission Port Call Database
- Shipping Lanes
 - Army Corps of Engineers
- Load Factors, Power, Hotelling Times
 - 2001 Port of Los Angeles Baseline Inventory
 - 2005 Statewide Ocean-Going Vessel Survey
 - Port-Specific Data from Ports; Air Districts

OGV Statewide Vessel Calls

Vessel Type	Number of Vessels	Number of Visits
Auto Carrier	225	750
Bulk	475	946
Container Ship	594	4744
General Cargo	196	721
Passenger*	44	687
Reefer	19	52
Ro-Ro	13	34
Tanker	372	1941



OGV Shipping Lanes





OGV Propulsion Engines

Vessel Type	Average Speed (miles/hr)	Main Engine Average Power (KW)
Auto Carrier	21.5	10,700
Bulk	16.7	8,000
Container Ship	26	30,900
General Cargo	18	9,300
Passenger*	22.1	Allocated to auxiliary engines
Reefer	23.1	9,600
Ro-Ro	17	11,000
Tanker	16.9	9,400





OGV Auxiliary Engines

Estimated	Average	Engine	l oad b	v Mode
	NVCIAGO		Loau b	y iviouc

Vessel Type	Auxiliary Engine Power (KW)	Hotelling	Maneuvering	Transit
Auto Carrier	2850	26%	45%	15%
Bulk	1776	10%	45%	17%
Container Ship	6800	18%	50%	13%
General Cargo	1776	10%	45%	17%
Passenger*	46670	16%	64%	80%
Reefer	3900	32%	45%	15%
Ro-Ro	2850	26%	45%	15%
Tanker	1985	26%	33%	24%

^{*} Values in this table represent average values. Where possible, engine specific data are assigned in preference to average values.





OGV Fuel Assumptions

- Passenger Ships
 - 92% Residual Oil Usage
 - 8% Marine Gas Oil
- All Others
 - 75% Residual Oil
 - 25% Marine Gas Oil
- Source: ARB 2005 OGV Survey

OGV Emission Factors

- Emission Factors (assigned by fuel, mode, engine type)
 - ENTEC EU Report
 - Data analysis conducted by Starcrest and ENVIRON
 - ARB analysis of multiple data sources
- Consistent with Port of Los Angeles Baseline Inventory
 - Auxiliary Engine HFO PM Emission Factor
 - Port of LA used 0.8 g/kw-hr
 - ARB uses 1.5 g/kw-hr
 - Based upon reanalysis of USEPA data upon which the emission factor was derived

OGV Emission Factors

Main Engine Emission Factors – Transit Mode (g/kW-hr)

Engine Type	Fuel Type	РМ	NOx	SO2	НС	СО	CO2
Slow Speed	HFO	1.5	18.1	10.5	0.6	1.4	620
Medium Speed	HFO	1.5	14	11.5	0.5	1.1	677
Composite EF	HFO	1.5	17.9	10.6	0.6	1.4	623

Main Engine Emission Factors – Maneuvering Mode (g/kW-hr)

Engine Type	Fuel Type	РМ	NOx	SO2	НС	СО	CO2
Slow Speed	HFO	1.5	14.5	11.6	1.8	1.4	682
Medium Speed	HFO	1.5	11.2	12.7	1.5	1.1	745
Composite EF	HFO	1.5	14.3	11.7	1.8	1.4	685

Auxiliary Engine Emission Factors – Transit, Maneuvering, and Hotelling (g/kW-hr)

Engine Type	Fuel Type	РМ	NOx	SO2	НС	СО	CO2
Medium Speed	HFO	1.5	14.7	12.3	0.4	1.1	722
Medium Speed	Marine Distillate	0.3	13.9	2.1	0.4	1.1	690
	Marine Distillate						
Medium Speed	@0.1% S	0.25	13.9	0.4	0.4	1.1	690

OGV Forecasting

Controls

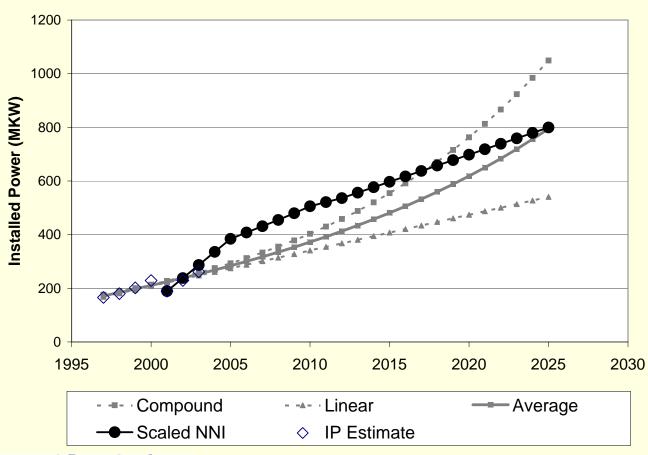
- IMO Emission Standards
- South Coast Vessel Speed Reduction

Growth

- California is experiencing a major increase in the amount of goods imported to our ports
- Estimates based upon the growth in installed power
 - Vessel-specific linkage to Lloyd's database
 - Extrapolated from 1997-2003
 - Consistent with NNI Report in South Coast
- Factor of 2-3 growth by 2020 in large Ports.

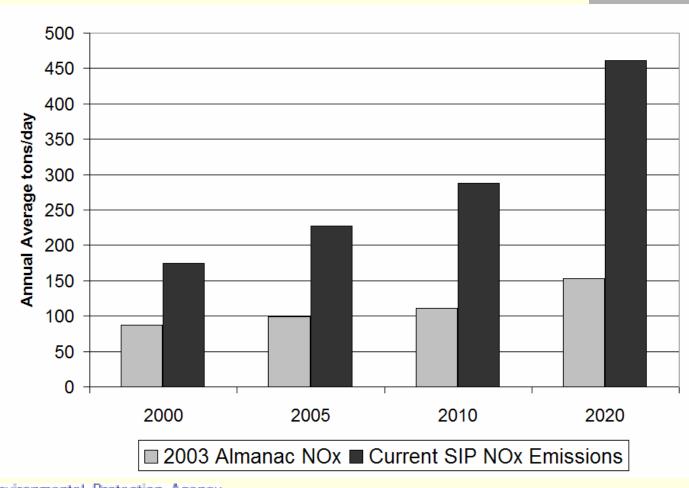
OGV Growth – South Coast

Modeled Forecasts of Installed Power, 1997-2025



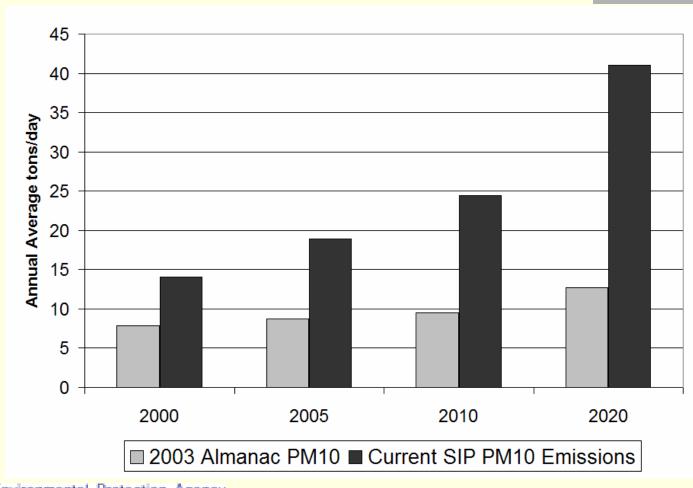


OGV NOx Emissions





OGV PM10 Emissions





Commercial Harborcraft Update

Lead Staff: Kirk Rosenkranz

CHC Overview

- Statewide, spatially refined, bottom-up approach
- Nine vessel types:
 - Commercial Fishing, Charter Fishing, Ferries / Excursion, Crew and Supply, Pilot, Tug, Tow, Work, Other
- Three emissions source types
 - Propulsion Engines, Auxiliary Engines
- Emissions out to 100 miles from shore
- Base Year Estimates
- Forecasted for attrition/deterioration, growth, control
- Inventory is currently being updated/improved

CHC Emissions Calculations

Calculation Method (Base Year=2004):

$$E = \sum P_i \times e_i \times Ee_i$$

P –population by vessel type

e – average number of engines by vessel type

Ee – emissions per engine

CHC Population by Vessel Type

- Population Estimates
 - U.S. Coast Guard documentation
 - CA. Department of Fish and Game commercial boat registrations
 - Port of Los Angeles emissions inventory
 - ARB 2003 Port / Harbor/ Marina Survey
 - ARB Survey (2002)

Vessel Use	Estimated Population
Commercial Fishing Vessels	2,727
Charter Fishing Vessels	563
Ferries/Excursion Vessels	416
Crew and Supply Vessels	64
Pilot Vessels	27
Tug Boats	128
Tow Boats	35
Work Boats	89
Others	136
Total	4,185



CHC Engine Number by Vessel Type

 Average number of engines by vessel type derived from ARB surveys and the Port of Los Angeles 2001 Inventory

Vessel Type	Auxiliary	Propulsion
Charter Fishing	0.75	1.75
Commercial Fishing	0.46	1.11
Crew and Supply	1.11	2.5
Ferry	1.23	2
Pilot	0.14	1.71
Towboats	1.17	2
Tugboats	1.59	1.92
Work Boats	0.32	1.45
Others	0.46	1.12



CHC Emissions per Engine

Average emissions

```
per engine type = \Sigma (emfac) x (load) x (annual activity) x (hp)
per vessel type total # of engines per vessel type
```

- Engine profiles by vessel type
 - Load
 - Rated Horsepower
 - Age and Useful Life
 - Annual hours of vessel use
 - Location of home port
- Emission factors
 - Based upon OFFROAD, but adjusted

CHC Example Engine Profile

Ferries / Excursion Vessels (data derived from survey)

HP Range	Average HP	Range (hp)	Average Age	Range (yrs)	Average Annual Use (hrs)	Range (hrs
< 50	45	35 to 50	30 (1974)	1965 to 1993	6040	600 to 8760
51 - 120	96.81	65 to 120	26 (1978)	1939 to 2002	1448.75	100 to 5000
121 - 175	165	160 to 175	32 (1972)	1943 to 2001	1347	375 to 250
176 - 250	224.29	190 to 250	16 (1988)	1969 to 2002	1641.43	50 to 8760
251 - 500	384.8	280 to 500	16 (1988)	1960 to 2000	1325.1	50 to 6467
501 - 750	658.39	550 to 740	18 (1986)	1973 to 2002	1524.46	100 to 400
751 - 1000	930	930	19 (1985)	1985	2000	2000
1001 - 1500	1285	1285	2 (2002)	2002	2500	2500
1501 - 2000	1699.23	1535 to 2000	1999	1989 to 2002	2720.38	1500 to 362
2001 - 3000	2498.5	2300 to 2682	1999	1996 to 2001	3125	2000 to 400
> 3000	3110	3110	5 (1999)	1999	2500	2500
Ferry / Exc	ursion Vessel	Auxiliary En	gine Profile As	sumptions De	rived from Survey	
HP Range	Average HP	Range (hp)	Average Age	Range (yrs)	Average Annual Use (hrs)	Range (hr
< 50	26.82	10 to 50	12 (1992)	1943 to 2002	1309.61	20 to 3833
51 - 120	81.56	60 to 101	19 (1985)	1954 to 2002	1049.94	10 to 2500
121 - 175	147.33	133 to 165	12 (1992)	1985 to 2001	1720.22	1200 to 250
176 - 250	206.43	185 to 250	11 (1993)	1985 to 2000	1305.71	120 to 250
251 - 500	400	400	13 (1991)	1981 to 2001	600	600



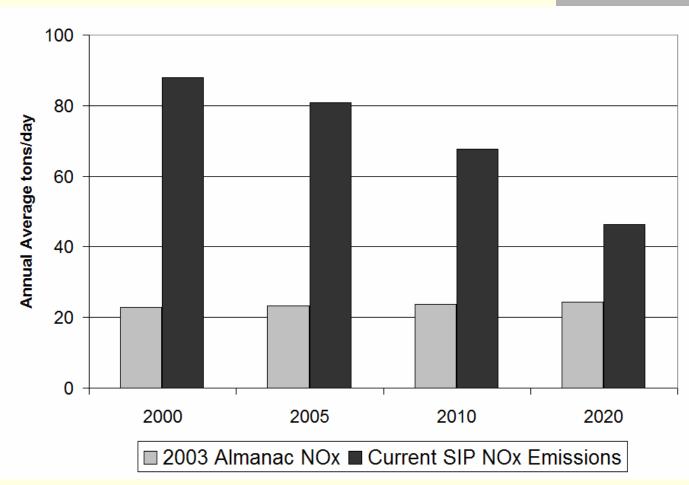
CHC Emission Factors

- Use ARB OFFROAD emission factors
- Adjusted for more appropriate cycles (from C1 to E3, or D2)
 - Adjust to "E3" marine cycle for main engines
 - 1.19 for NOx, no adjustment for HC, 0.73 for CO, 0.94 for PM
 - Adjust to MARPOL & EPA Standards for main engines
 - Adjust to "D2" marine cycle for auxiliary engines
 - No adjustment for NOx, 1.19 for HC, 1.03 for CO, 0.84 for PM
- No changes to:
 - Differentiate between "wet" & "dry" exhaust
 - Differentiate between 2 & 4 stroke engines

CHC Forecasting

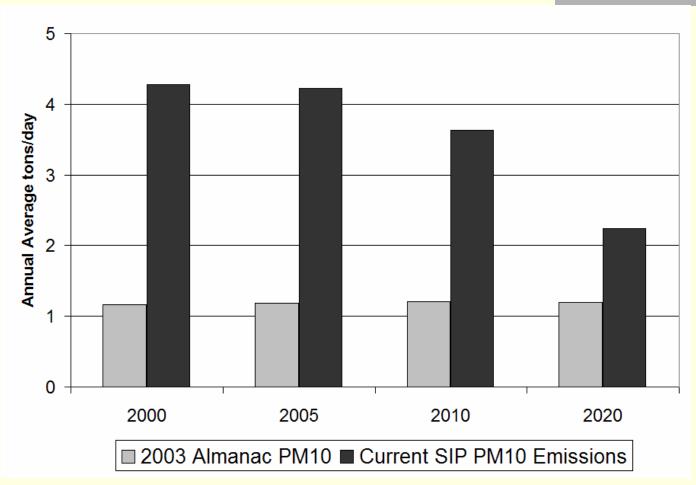
- Control
 - Engine standards
 - Fuel correction factors
- Growth
 - Tugboats assumed flat
 - Other vessel types used district growth rates

CHC NOx Emissions





CHC PM10 Emissions





Marine Inventories – Next Steps

- Ocean-Going Vessels
 - Provide more detail in EIC codes
 - Incorporate emissions from on-board incineration and warming of bunker fuel
 - Periodic revisit of growth rates
- Commercial Harborcraft
 - Currently engaged in comprehensive emissions inventory update
 - Support regulation: board date early 2007